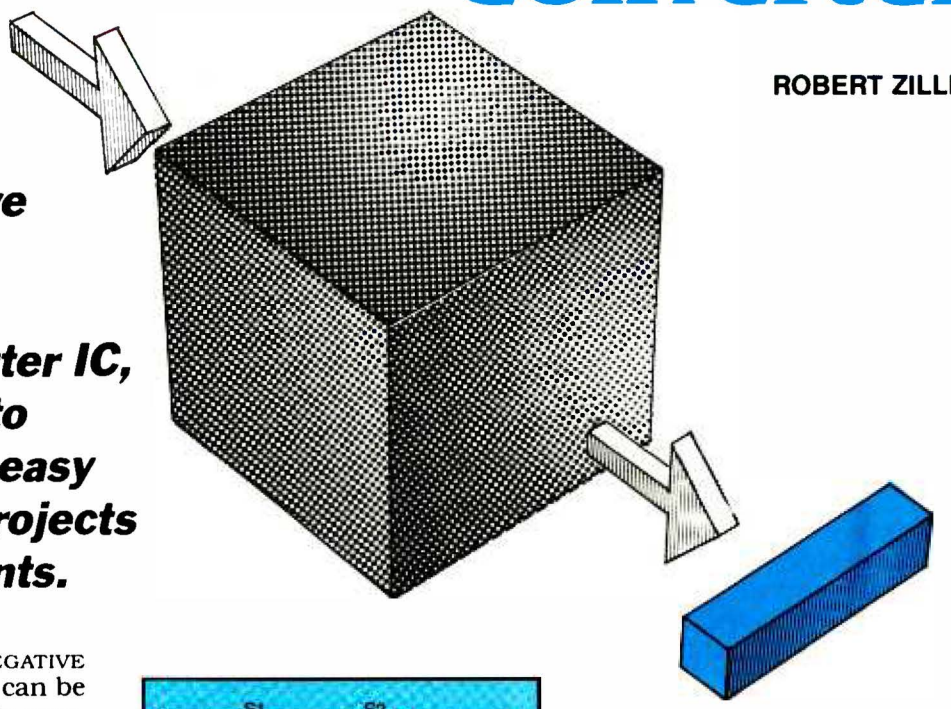
BUILD THIS Negative Voltage Converter

ROBERT ZILLER



Build a negative voltage supply from a CMOS voltage converter IC, and obtain up to −12 volts the easy way for your projects and experiments.

THE REQUIREMENT FOR NEGATIVE voltage in some projects can be annoying because it adds components that you'd like to avoid. In personal computers, for example, there might be a requirement for 20 amperes of +5 volts, but only 0.3 amperes of −5 volts, and a similar relationship holds for many electronic projects. The positive supply powers the digital and analog circuitry, but typically only a few negative milliamperes are needed to power operational amplifiers, digital-to-analog converters, or RS-232C interfaces.

The charge pump

A simple method for obtaining negative voltages is with the charge pump or negative voltage converter, diagrammed in Fig. 1. Capacitor C1 charges to the input voltage during the half cycle when switches S1 and S3 are closed. (Switches S2 and S4 are open during that half cycle.) During the second half cycle, switches S2 and S4 are closed and switches S1 and S3 are open. Charge is then transferred from C1 to C2 through ten charging (pumping) cycles until the voltage on C2 reaches a negative voltage value equal to the positive input voltage value.

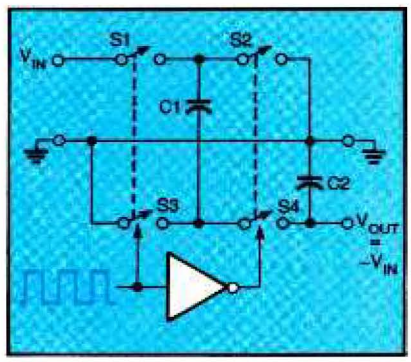


FIG. 1—SIMPLIFIED DIAGRAM OF A CHARGE PUMP that functions as a negative voltage converter.

Monolithic charge pumps

The 7660 industry standard monolithic CMOS voltage converter includes the components needed to make a discrete charge pump, saving board space and construction time. It offers an output of −5 volts from a +5-volt source. These devices are still available, but they are not recommended for new designs. The 7660 has been superseded by the improved 7660—the ICL7660S CMOS super voltage converter made by Harris Semiconductor. It can provide negative voltages for an input range of 1.5 to 12 volts.

Figure 2 applies to both versions except that the RC oscillator of the ICL7660S has a BOOST pin for higher switching efficiency. Both contain a series DC power supply regulator, an RC oscillator, a voltage-level translator, and four output power MOS switches. Switch S1 is a P-channel device, and switches S2, S3, and S4 are N-channel devices. A logic network senses the most negative voltage in the device and ensures that the output N-channel MOS switch source substrate junctions are not forward biased. This feature prevents

www.americanradiohistory.com

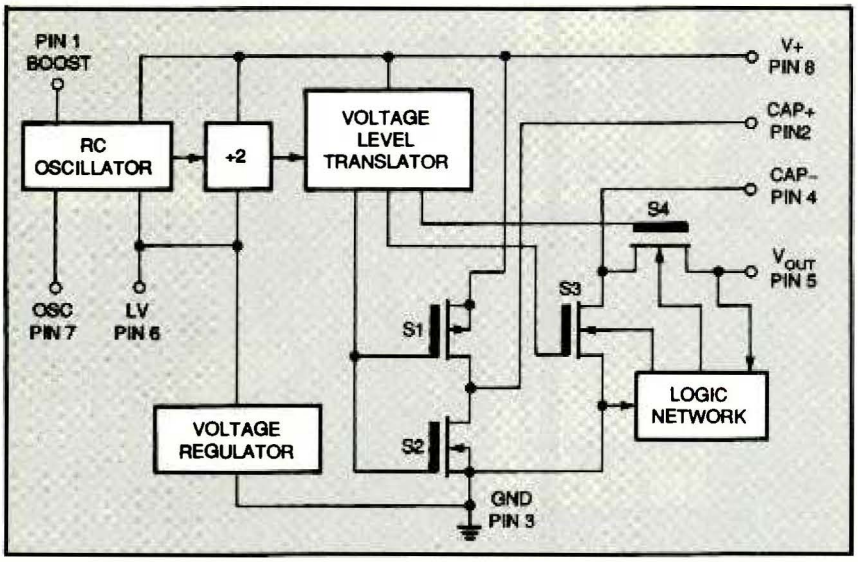


FIG. 2—BLOCK DIAGRAM FOR 7660-type CMOS voltage converters. Pin 1 in the 7006 is NC, but in the ICL7660S it is the BOOST pin for increasing switching frequency.

latchup. The RC oscillators of both versions, when unloaded, oscillate at a nominal frequency of about 10 kHz when the input supply is 5 volts.

The ICL7660S converts positive to negative voltage for an input range of +1.5 volts to +12 volts. This conversion produces negative output voltages of −1.5 volts to −12.0 volts. Only two non-critical external capacitors are needed for the charge pump and charge reservoir. These can be 10 μF aluminum electrolytic capacitors. Both 7660s can also function as voltage doublers, and the ICL7660S will generate output voltages up to +22.8 volts with a +12-volt input. Both versions can approach 100% conversion efficiency.

Putting it to work

Looking back at Fig. 1, when the 7660 is connected to a load, the load takes some of the charge from capacitor C2 which is partially replaced by capacitor C1. This replacement action results in voltage ripple at the switching frequency and a slightly reduced output negative voltage. If this ripple will create problems in the host circuit, the output of the 7660 can be connected to a voltage regulator or larger capacitors. Because the output of a 7660 is unregulated, a +5-volt input will produce only about a −4.5-volt output into a 10 milliampere load.

Figure 3 is a simple charge pump schematic based on the ICL7660S. Capacitors C1 and C2 have values of 10 μF. This three-component circuit is as simple as a standard IC voltage regulator circuit, and a lot simpler than a full-fledged negative power supply.

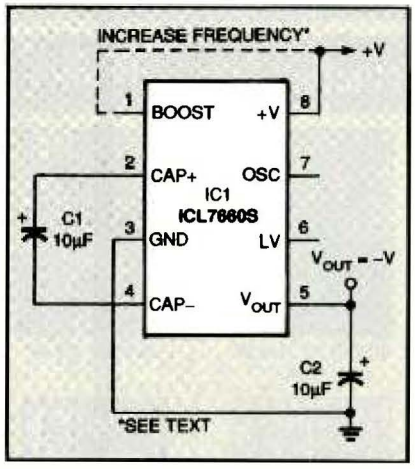


FIG. 3—SIMPLE NEGATIVE voltage converter circuit with its external capacitors. Negative voltage up to −12 volts can be obtained from output pin 8.

The 10-kHz frequency of the 7660S can be increased 3.5 times by tying BOOST pin 1 to +V (pin 8). It can be lowered by adding an external capacitor to the OSC terminal. The oscillator frequency can also be increased by overdriving it from an external clock. Refer to the manufacturer's data sheet to find out how to do this. The low voltage LV terminal can be tied to ground to bypass the internal series regulator to improve low-voltage operation. At medium to high voltages (+3.5 to +12.0 volts) the LV pin is left floating to prevent latchup.

Do's and don'ts

Here are some recommendations to assure that your negative voltage converter works correctly:

1. Do not connect the LV pin 6 to ground for supply voltages greater than 3.5 volts.
2. Do not short circuit the output to the +V supply for supply voltages greater than 5.5 volts for extended periods.
3. When using polarized capacitors, the + terminal of C1 must be connected to pin 2 of the 7660, and the + terminal of C2 must be connected to ground.
4. Do not allow the output at pin 5 to go more positive than GROUND pin 3 or the device will latch up. A 1N914 or equivalent silicon diode in parallel with C2 will prevent latchup under these conditions. Connect the anode to output (V_{OUT}) pin 5 and the cathode to LV pin 6. Ω

PARTS LIST

IC1—ICL7660S CMOS monolithic voltage converter, integrated circuit
C1, C2—10μF, 35 WVDC electrolytic capacitor
Wire, solder, circuit-board materials, etc.

www.americanradiohistory.com